中亚干旱区环境演变与湖泊生态学术研讨会

The workshop of the environment evolvement and hydro-ecology in the arid zone of central Asia

2008年8月21-25日

中国·新疆·乌鲁木齐

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主办单位： 中国科学院人事教育局

承办单位： 中国科学院新疆生态与地理研究所

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Introduction:

Due to the global climate changes and the rapid development of social economy, the environment evolvement and water problems of Central Asia regions have become more serious, especially the lack of water resources, frequent climatic hazards, flooding, drought and other water related problems have been the main limiting factors for the sustainable development of the economy and constructing the harmonious society of this region. Therefore, the studies of the regional response on the global warming and its countermeasures, the works on the impact of the interactions between the human activities and natural environment on the regional environment evolvement and hydro-ecology have gained increased attention of the many international organizations, governments, and scientists in the world. Considering those situation, Chinese academy of Science will be holding a workshop about "the environment evolvement and hydro –ecology in the arid zone of Central Asia" on August 21st ~ 25th, 2008 in Urumqi, Xinjiang, China. In this conference, it is planed to mainly discuss the environment evolvement and hydro-ecology of Central Asia arid land, and the impact of human activities on the atmosphere, soil, water, biodiversity, and its feedbacks on the human society. Finally, to providing optimize management models for the lake ecosystem of Central Asia arid land.

Goal of conference: To strengthen the mutual understanding and International Corporations between the scientists in the related research fields at home and on abroad.

Conference main topics:

- Research dynamics and latest development trend of the environment evolvement of Central Asia arid zone;
- Research dynamics and latest development trend of hydro-ecology in Central Asia arid zone ;
- The physics, chemistry, and biological changing process of regional environment evolvement in Central Asia arid zone ;
- Soil salinization and lake salinity changes in Central Asia arid zone ;
- The impact of the interactions between human activity and climate changes on lake ecosystem in Central Asia;
- Application and construct of lake ecosystem management and information system in Central Asia;
- Terrestrial and aquatic plant's productivity and its changes in Central Asia arid zone ;
- Prognostication and simulation of lake ecosystem changes in Central Asia arid zone ;
- Exploitation of lake basin, environmental treatment, and regional sustainable development of Central Asia;
- Optimized management model for Lake Basin in Central Asia arid land.

CONTENTS

New approaches in management of Barsakelmes wildlife reserve in conditions of environmental change and chemical pollution in northern part of the Aral Sea region (Kazakhstan)

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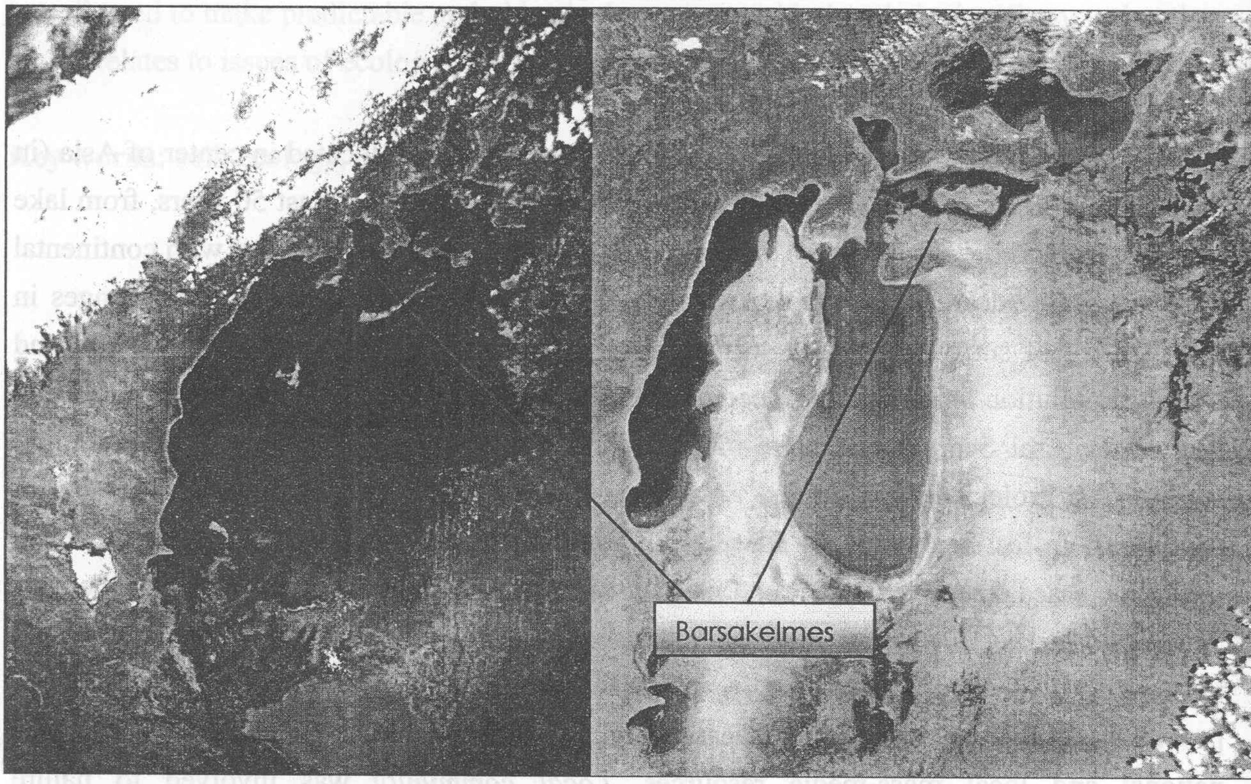
Introduction

Barsakelmes Strict Nature Reserve (IUCN category 1A) is located in center of Asia (in the Aral Sea area) – region of catastrophic environmental changes in last 50 years, from lake area to waterless desert. In last 10 years the island territory of reserve joined with continental area because of decrease of the sea water level, water drop caused the climate changes in 150-200 km of surrounding land surface. The processes of aridization, desertification and chemical pollution brought a lot of ecological troubles to local people living in north and east part of the Aral Sea area. In spite of ecological disaster the Nature Strict Reserve could survive as a Protected Area needed for conservation of biodiversity in such new ecological conditions. In last several years Kazakhstan *government* expanded Reserve territory in ten times, increased financial support and number of staff, rehabilitated northern part of the Aral Sea. *Reserve administration* built an effective protection system for whole continental territory, provide additional fundraising, attract broad circle of scientific institutions for providing ecological monitoring research and organized wide propagandistic activity in national and local mass-media resources. *Local community* was involved to nature conservation in a region through some local NGOs as well as international organization. At present time conservationists propose an idea to establish a biosphere reserve on the base of Barsakelmes Nature Reserve.

1. Brief description of wildlife reserve "Barsakelmes"

Localization, size and accessibility of nature reserve Barsakelmes. Cluster parts of nature reserve (Barsakelmes peninsula, former Kaskakulan island and the Syrdarya delta, as planned protected area) are located in the Northern part of Eastern coast of the Aral Sea. Total area of nature reserve consists of 160 826 ha. Barsakelmes part includes previous territory of nature reserve (16 975 га) and some part of dried Aral sea floor with total area of 50 884 ha, (reserve core 37 725 ha and buffer zone 13 159 ha). Kaskakulan part occupies 109 942 ha of land (reserve core is 68 154 ha, and buffer zone 41 788 ha). These two separate parts of nature reserve are connected by ecological corridor. Administratively nature reserve is located in Aral district of Kyzylorda Province. Administration of nature reserve is located in Aralsk City (36 hours from Almaty by railway). Accessibility of nature reserve territory: driving car to Karateren village (180 km) and further 20 km to west-northwest (Syrdarya delta) or 50 km to south-west (Kaskakulan), or 120 km to south-west (former Barsakelmes island). The field road (sand, clay) from Karateren village to Kaskakulan and Barsakelmes part goes through dried sea bottom, so in spring or autumn it might be hard because of rains and wind storms.



Satellite photos of Aral Sea Area in 1961 and 2006

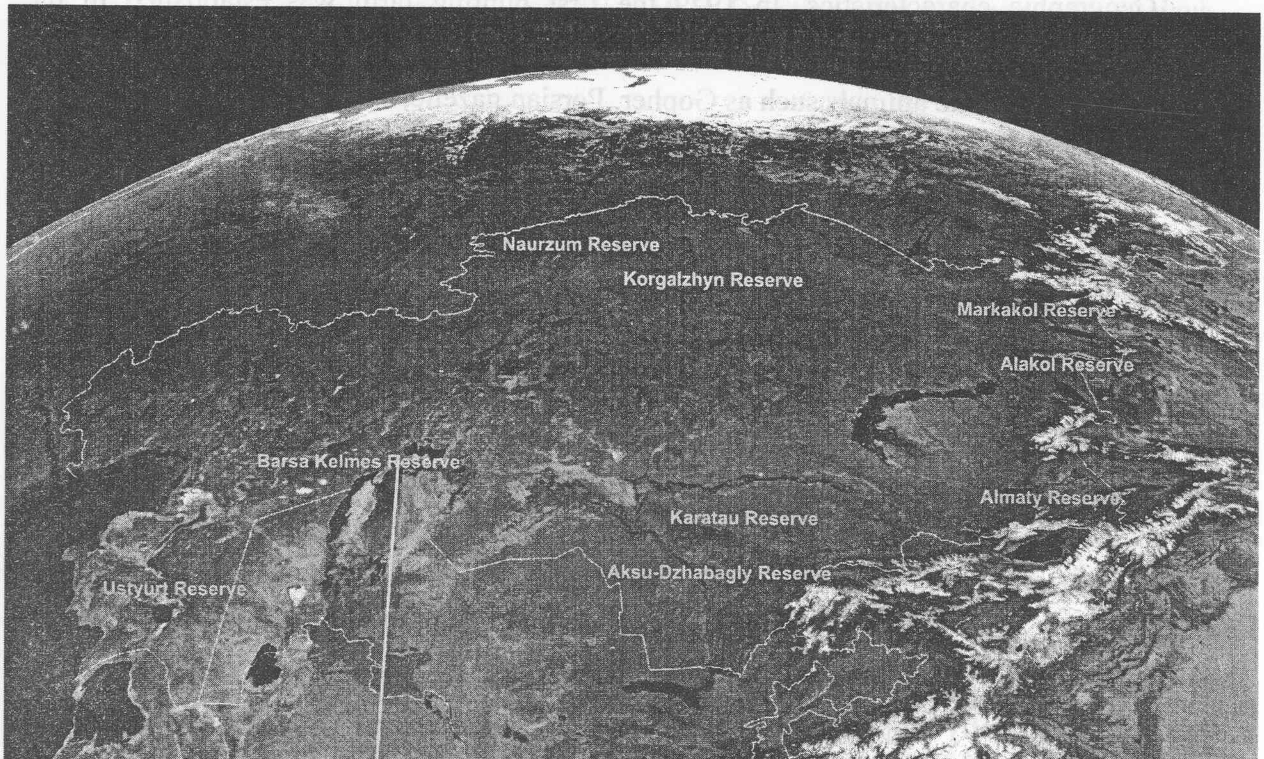


Fig 1. Map-scheme of Strict Nature Reserves of Kazakhstan

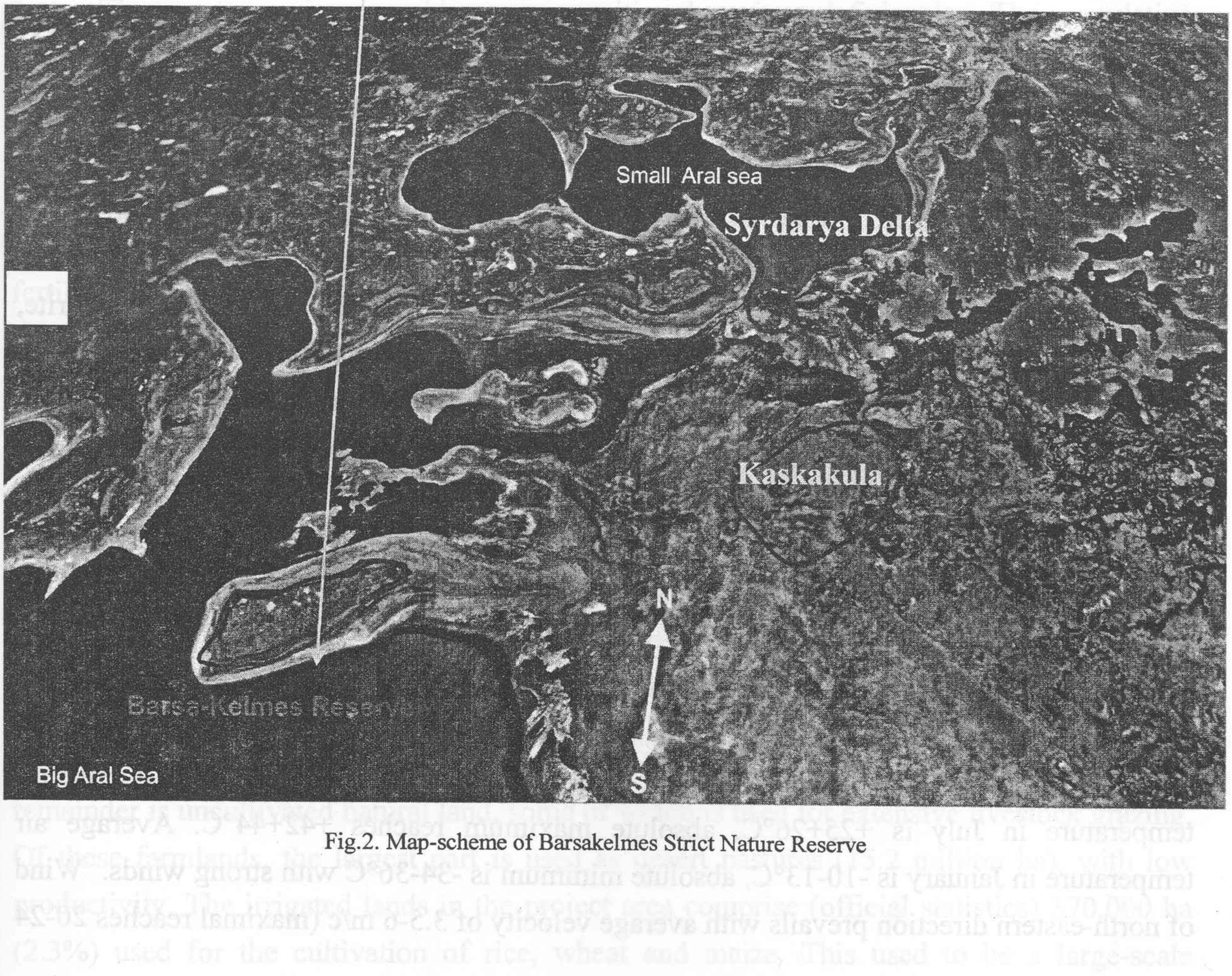


Fig.2. Map-scheme of Barsakelmes Strict Nature Reserve

Geographic characteristics. In 1929 the first hunting farm was established in the Barsakelmes island for the purpose of breeding and trade of regional wild animals. Some wild and big vertebrate animals such as Gopher, Persian gazelle, saiga, brown hare, partridge, pheasant were brought and released in the island. Later on the reserve "Barsakelmes" reserve was established by Kazakhstan Government in 1939 as a strict nature protected area. Asiatic wild ass (*Equus onager*) was brought from Turkmenistan and released in island in 1953 for re-establishing the north population of onager.

Topography. Territory of the wildlife reserve is situated in the plain and includes peninsula Barsakelmes, former Kaskakulan island with dried seabed of the Aral Sea and the Syrdarya river mouth. The highest elevation is 108 m above sea level, it is located in the Barsakelmes former island. Relief of the peninsula is divided into two parts: the southern – high plateau and the northern – undulating plain crossing from south to north by valleys of temporary streams. North-western, northern and eastern coasts are bordered by sand dune belt. South-western and southern shores have abrasion character. There are shallow drainless depressions at the surface where takyrs and solonchaks are formed. The original coast is separated from gently dipping marine plain by well marked terrace. Primary marine plain is formed in the dry seafloor with slightly inclined surface partly with drying cracks. Relief of the eastern coast is hillock-low-hummocky sand dunes oriented almost in meridional direction. Alluvial plains are differed by slight incline with formation of erosion and accumulative processes.

Geology. Basal massif of Barsakelmes island is composed by Oligocene gypsiferous argil, aleurite, sandstone. Northern part is composed by fine grained sand, aleurite and loam with black silt interlayer. Marine and lacustrine sediments of former coasts are represented mostly by medium-grained and coarse-grained sand. Quaternary and recent deposits spread in the plain. Primary marine plains are composed by different grain sand, aleurite, agglomerations of shells, restrictedly by clay and rubble – pebble material.

Soils. Gray-brown desert soils of different salinity and texture are represented in the original coast of the peninsula. Most widespread are gray-brow alkaline soils; takyrs, solonchaks are represented as well. Sandy soils occur in the northern, western and eastern coasts of the former island. Marsh and coastal solonchaks, coastal sand and coastal soils with blown sand cover are formed in the dry seabed. Flood-plain meadow, meadow-swamp and swamp soils are presented in the Syrdarya delta.

Climate. Climate is temperate with long hot summer, relatively cold winter, insignificant cloudiness, low precipitation that is typical for the northern deserts. Annual precipitation is low (126-128 mm), most of them is related to cold time of year. Average air temperature in July is +25+26°C, absolute maximum reaches +42+44°C. Average air temperature in January is -10-13°C, absolute minimum is -34-36°C with strong winds. Wind of north-eastern direction prevails with average velocity of 3.5-6 m/c (maximal reaches 20-24 m/c). Snow cover is unstable, strong winds blow off it. Duration of snow cover is 80-90 days. Frost zone is 45 cm, complete defrosting is marked in the end of March.

2. The impacts of global environmental change and chemical pollution in the region of wildlife reserve "Barsakelmes"

2.1. Socio-economic changes

The total population around the North Aral Sea area is estimated between 150,000 to 200,000 people. The settlement pattern ranges from villages of a few houses to the cities of Novokazalinsk, Aralsk, and Kzyl Orda. The population was essentially stable and the birth rate (1995) of 26 per 1000 slightly above the national average of 24. Migration out of the region began to increase in 1970 with declining environmental conditions and reached a peak between 1975 and 1985. Literacy is high, since most children complete primary school. More than 80% of households have more than one income source. Considerable work time is devoted to subsistence activities (livestock tending, vegetable growing, fuel wood gathering), some of which provide ancillary income. Average 1997 households income was about USD 920 or per capita about USD 178. The general health of the people in Aralsk and Kazalinsk Rayons has always been below the national average, but has declined further in the last 30 years. The most prominent problems are nutritional, serious deficiencies. The cumulative result of this is an increase, in the last ten years, in miscarriages (from 21 to 35 per 1000 pregnancies), congenital anomalies (4.5 to 10.2), premature births (4. 1 to 6-5), and stillborn babies (8.5 to 9.7). The infant mortality rate of 28.3 per 1000 exceeds the national average of 26.4. Other health problems have been blamed on the high level of nitrates in the water of the river and canals, consumed untreated by 17% of the rural population. The nitrates, residues of fertilizer applications in the upstream agricultural massifs, are reported to cause birth and growth defects, and oral and intestinal sores. The rate of infection of numerous diseases including parasitic infections is well above national averages in the Aralsk and Kazalinsk Rayons. Examples include respiratory, gastrointestinal, typhoid and paratyphoid fevers, viral hepatitis, and internal parasites. Many of these increased by 10 to 30 times during the 1970s. The central government and the oblast health department have upgraded health services in the last 20 years with the construction of several new hospitals and clinics. Unfortunately, the general economic situation in the country and the lack of local funds has left these facilities badly understaffed and lacking in essential supplies.

The total land area of the Syrdarya basin within KzyI Orda and South Kazakhstan Oblasts is 27.7 million ha. About 60% of this (15.7 million ha) is occupied by farmlands, the remainder is uncultivated natural land, some of which is used for extensive livestock grazing. Of these farmlands, the largest part is used as desert pastures (15.2 million ha), with low productivity. The irrigated lands in the project area comprise (official statistics) 370,000 ha (2.3%) used for the cultivation of rice, wheat and maize. This used to be a large-scale mechanized type of irrigated agriculture, with cultivation in relatively large basins (2 ha). Since the large-scale mechanized agricultural system virtually collapsed in the early nineties, the actual cropped area decreased considerably. Existing co- operatives struggle with financial constraints, lack of inputs, and lack of spare parts and shortage of labor. Yields per hectare have decreased, but accurate data of the actual output and cultivated area are lacking. The total irrigated area in the project area is estimated to be about 250,000 ha.

2.2. Changes of the Aral Sea level

The current lowering of the Aral Sea has begun more than 40 years ago – scientists have begun discussion this since 1961. The main reason of the water level fall was understood in that time, it was rapid development of the extensive irrigated agriculture along the two main Central Asian rivers Amudarya and Syrdarya, and both of them flow to Aral Sea. The water balance of Aral Sea consisted of the income from river water, atmospheric precipitates and underground flowing with the deduction of evaporation loss. Evaporation always plays very important role in Aral Sea water-fillness in the arid area of waterless deserts. From the beginning of 20th century to 1961 the evaporation loss was in average 66.1 km^3 per year, but income consisted of 56 km^3 of the river water, 9.1 km^3 of the precipitation, from 0.1 to 3.4 km^3 of underground water annually. In general, there was an approximate equality between water income and outcome in Aral Sea. That equality provided the water level stability of this lake.

The volume of the river water income to the Aral Sea was going to decrease because of water use for the agricultural needs after the building of irrigation canals. From the 1961 to 1970 the river water income was in average 43.3 km^3, but from 1971 to 1980 it was only 16.7 km^3. In the first half of 80th the river flow to Aral Sea was almost discontinued, in that time it was 2 km^3 per year, in which connection the water of Amudarya did not reach Aral and former full-flowing Syrdarya became small river. From the 1986 to 1995 the river flow annually was 7 km^3 in average. Syrdarya River had maximum volume of water in 1993 (7.8 km^3), 1994 (7.66 km^3) and 1998 (7.23 km^3) because of rainy years and region economic troubles in last ten years. But in general, during last 40 years the water balance was destroyed because of decrease of river water and evaporation.

Loss of the water balance of Aral Sea stimulated rapid decrease of water level from the mark +53 m above sea level that was usual for stable period. From 1961 to 1974 the level of lake was going down on 27 cm each year in average, from the 1975 to 1985 this annual lowering was 71 cm, from 1986 to 92 it was 88 cm per year. In that time the total water level drop was 16 m. As a result of that continued from the west to east Kokaral Island joined with west coast in 1968, in 1990 this new peninsula reached east coast after drying up of the Berg's strait. Thus, the former whole water area was divided on two parts: relatively small north part, named as Small Aral Sea (or North Aral) and rather large south part Big Aral Sea (South Aral). In that time (1990) the total water volume was 370 km^3, total surface was

40394 km^2, and North Aral Sea had 23.61 km^3 water volume and 3030 km^2 surface. The new period of the Aral Sea history began after that isolation of two parts. The changing of water level caused the changing of salt concentration in the water. The annual salinization was 10.2-10.3 ‰ until 1961. Besides, water salinization increased till 11.5 ‰ in 1970, 17.0 ‰ in 1980 and 30 ‰ in 1989. After that, in 1992 the average salinization for Big Aral Sea was 42.1‰, and for Small Aral Sea - 24.9 ‰. In the end of 1998 salinization was observed as 20.0 ‰ in Small Aral Sea and 46-48 ‰ in Big Aral Sea, though according to non-published information from Danish researchers the maximum salinization in south part of lake reached 56 ‰.

The drop of water level was the same for the all water area of Aral Sea until 1989. Later, after the isolation of north and south parts the process of water level changing became different in these two parts on speed. In spite of the drying up the Strait of Berg in 1989, the 4 km artificial canal existed. It was dug underwater for the shipping in the beginning of 1980^{th}. That canal was revealed, at the same time water level of Big Aral was going down and level of Small Aral was going up because of big income from the Syrdarya River. As a result, water began to flow through this silted canal from north part to south. Water removed silt from canal bottom and continued to wash out the bottom ground, increasing the width and depth of canal. In the spring 1992 the canal became 5 km length and 100 m width. So, this canal could reach the Syrdarya delta and change the flow direction of this river to south. In this situation Small Aral Sea would be dried up completely. The main part of population was located in north side of Aral Sea in Aralsk and Kazalinsk districts, so the disappearance of Small Aral Sea would be a very hard disaster for 150 thousand people with various economic, social and ecological consequences. (Now I would like to express my great thanks to Prof. Aladin, he was the first who recognized this danger and attract attention of local administration to this risk). The reaction of Kazakhstan government was rather rapid, local administration began to cover up with earth that canal and build the first dam between Kokaral and east coast in August 1992. In that time ground dam was 1 m height. Retrospective water balance of the north part of Aral Sea in 1988-1991 shows some decreasing:

a) water level from 40.50 m to 39.40,

b) water area from 3200 km^2 to 2 940 km^2

c) water volume from 25.42 km^3 to 22.58 km^3

d) evaporation – 10.58 km^3 total

e) Syrdarya water income 13.45 km^3 total (for 4 years)

f) water outcome to Big Aral Sea – 6.49 km^3

Total volume change of north part of Aral Sea from 1988 to 1991 was -3.62 km^3

In 1992 the difference between Big and Small Aral Sea water level became more than 2 m (Small Aral Sea – 39.0 m and Big Aral Sea – 37.1 m). Unfortunately, dam was destroyed many times by pressure of water from the North Aral. In That situation the water flow from the Small Aral Sea would allow the water level change until 37.0; it would be complete degradation of Aral Sea which could be divided on some isolated parts. In consequence, in 1993 the Institute Kazgiprovodkhoz worked out the pilot project of the Kokaral Crosspiece (dam-road). According to this project the ground dam was built again 3 m height (43.5 m above sea level on the top) and 12.7 km length and re-covered canal. Besides, the winter drawdown from the Toktogul Reservoir (Kyrgyzstan) in 1993/1994 allowed water tint through the dam and its break again.

In 1996 the dam destruction was repaired by the efforts of local administration initiative. In April 1997 the water level of North Aral reached mark 41.25 m above sea level, but dam was destructed again because of strong wind which increased water positive setup on 0.6 m; the break was 125 m length and 2 m depth. In the middle of 1997 the water level dropped till 40.5 m. In the autumn 1997 the ground dam was re-built. The International Fund of Aral Saving began to support dam construction from the second half of 1998. According to this project the dam was increased in height and width (20 m), the overflow hydraulic work must be done also. In the December 1998 the water level of North Aral reached 41.77 m, but South Aral Sea dropped to 37 m. The most high water level of Small Aral Sea was observed in the April 1999 – 42.3 m above sea level. Besides, the big storm in April 20 destroyed non-finished Kokaral dam, as the result more than 7 km^3 sea water went out during few months and water level dropped in the middle of summer till 40.0 m. Unfortunately, 50 workers stayed in the storm on the dam – 2 people died and 20 people were evacuated from the roof of cars and tractors by helicopters and boats. Building company lost all equipment (cars, tractors, cranes, etc.) in salt water and silt. Since 2001 the World Bank supports the special project on Syrdarya and north Aral Sea in the amount of US 64.5 million; one of the goal is devoted to re-construction of Kokaral dam. It was built in 2006 and water level increased to about 42 m above sea level.

In general, the retrospective water balance of the north part of Aral Sea in 1992-2006 shows:

a) water level increase from 39.00 to 42.3 m

b) water area from 2840 km^2 to 3500 km^2

c) water volume from 21.54 km^3 to 28.71 km^3

2.3. Transformation of soil cover

For the last 20 years Aral Sea Region draws the attention of not only Kazakhstan scientists, but also experts of the different countries of the world. It is connected to catastrophic Aral Sea level decrease, development of desertification processes, and that standard of living of the population got worse. Typical feature of Aral Sea region desertification is aeolian and hydrogenic salinization of lands. On the dried sea bottom there is a formation of new natural complexes of desert type. Reduction of Syrdarya River flow and absence of incoming fresh waters has resulted in amplification of drying up of the territories, disappearance of lakes, decrease of ground water level and increase of mineralization of the river, ground and sea waters. In recent years the type chemism of river water in a lower reaches of Syrdarya River has changed into sulphate-sodium instead of hydro-carbonate-calcium has changed. In ion structure of river water salts the quantity of chlorine increased that worsens its irrigation qualities. The soil cover of the region suffered considerable changes. Many non-saline soils became into saline and the area occupied by solonchaks was increased. Practically there are no unsalinized soils on this territory at present. Desertification is accompanied by a decrease in fertility of hydromorphic soils. Humus decreased by 30-35% in 50-cm layer of meadow and swamp soils (Akhanov and Karazhanov, 1998). As a result, the nitrogen level also decreased (Nekrasova, 1979). Drying up of the Aral Sea has resulted in an exposure of its bottom where soils begin to be formed. Studying soils' various stages of drying up allows to learn the process of formation and development of soils from a zero point, to understand the genesis of soils, and to reveal features of soil formation in a desert zone. Depending on granulometric compound of adjournment and relief of the sea bottom it is possible to observe several types of soil transformation. On sandy grounds the following evolution of soil cover is observed: marsh solonchaks > seaside primitive soils > seaside primitive soils with blown sandy cover > sands. On clay grounds soils develop through the following stages: marsh solonchaks > seaside solonchaks > solonchaks common > solonchaks takyr-like > takyr-like soils. The presence of negative relief elements marsh solonchaks transform to shor solonchaks with the time (Karazhanov, K. and A. Haibullin, 2001).

2.4. Flora and vegetation

2.4.1. Flora. According to botanical-geographic regionalization the territory of State reserve Barsakelmes is situated in the Iran-Turan sub-region of Sahara-Gobi desert region in North Turan province – West-North Turan sub-province, North-Aral (peninsula Barsakelmes) and East-Aral (former islands Kaskakulan and Uzunkair) districts. According to publications and last investigations in the dry seabed of the Aral Sea flora of vascular plants of Barsakelmes peninsula and Kaskakulan area consists of 298 species listed belong to 50 families and 176 genera. There are 260 species in Barsakelmes peninsula and 118 plant species – in the area of Kaskakulan. Species from Chenopodiaceae, Asteraceae, Poaceae, Brassicaceae, Polygonaceae families are prevailing (Table 1). The most imported genera are: *Calligonum* (16 species), *Artemisia* (11), *Atriplex* (11), *Astragalus* (8), *Strigosella* (7), *Salsola* (6). There are 14 endemics: *Artemisia aralensis, A.scopiformis, A. quiqueloba, A. camelorum, Atriplex* *pratovii, A. pungens, Petrosimonia hirsutissima, Astragalus brachypus, Tulipa borszczovii, Calligonum crispatum, C. palibinii, C. humile, C.spinulosum, Corispermum laxiflorum.*

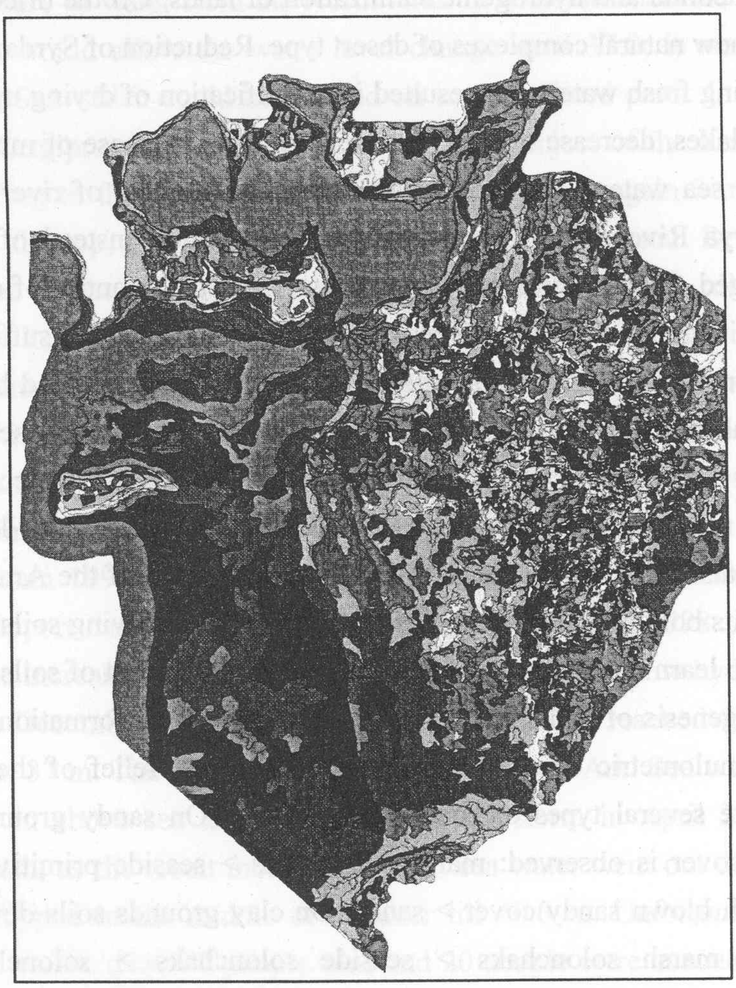


Fig. Map of dynamics of a soil cover: grey color – not changed territories, light color – positive bonitet, dark color – degradation (Pachikin, Krivenko, Erokhina O., Shildebaeva S., 2005)

Table1 . Specter of leading families of State reserve Barsakelmes flora

Family	Number of genus	Number of species	% from total number
Chenopodiaceae	24	60	20.1
Asteraceae	23	36	12.1
Brassicaceae	21	30	10.1
Poaceae	19	29	9.7
Polygonaceae	5	25	7.4
Fabaceae	10	18	6.0
Boraginaceae	9	12	4.0
Ranunculaceae	7	8	2.7
Liliaceae	3	7	2,3
Total	121	225	74.4

2.4.2. Vegetation. The vegetation is depended on geomorphology, relief and soil conditions. Description of vegetation is discussed in the limits of following structural units: original coast of the peninsula (plateau and low plain); the Aral marine terraces (belt of hummocky sand dunes with vegetation of the northern, western, eastern coast of the peninsula); the dry seafloor surrounding the peninsula; the original coast and the dry seabed of Kaskakulan area.

2.4.2.1. VEGETATION OF BARSAKELMES PENINSULA: Vegetation of plateau and low plain. The important feature of vegetation is complexity. Zonal vegetation is comprised by three basic species - *Artemisia terrae-albae, Anabasis salsa, Agropyron desertorum*. Saxaul (*Haloxylon aphyllum*) often occurs in sagebrush communities. Most widespred is *Agropyron desertorum - Anabasis salsa - Artemisia terrae-albae* community. *Artemisia terrae-albae* and *Anabasis salsa* communities dominate in the low plain, regular alternation of them is caused by texture, degree of salinity and alkalinity of grey-brown soils (Kuznetsov, 1979). Communities of sagebrush (*Artemisia terrae-albae*) are prevailing in plateau and low plain. They correspond to zonal grey-brown soils, sometimes alkaline or gypsiferous. Floristic composition of them comprises 60 species of heist plants, 5 species of lichens and 2 species of fungi. Plant communities consist of 6-7 species of 35-70% coverage. Sub-dominants of sagebrush communities are represented usually by *Eremopyrum orientale, Lepidium perfoliatum, Stipa lessingiana, Agropyron desertorum, Anabasis salsa, A.a phylla, Haloxylon aphyllum*. Communities of *Anabasis salsa* occur on grey-brown alkaline and solonchakous soils. There are 3-7 (13) species in plant communities, vegetation coverage is 10-25%. Floristic composition of them comprises 53 species of heist plants, 6 species of lichens and 2 species of fungi. Sub-dominants of communities usually are *Artemisia terrae-albae, Eremopyrum orientale*. Dwarf semishrubs, ephemerals and ephemeroids are very important among life forms of plant communities. Intrazonal vegetation is distributed in solonchaks. Solonchaks of north-western part of peninsula are vegetated by *Halocnemum strobilaceum, Limonium suffruticosum* communities. Saltwort vegetation covers takyr-like solonchaks in the north-eastern part (*Halocnemum strobilaceum, Climacoptera aralensis, C.brachiata, Eremopyrum triticeum, Senecio noeanus*) with coverage 25-30%. Badlands with sulphate solonchaks are distributed in the areas of wedging out Tertiary argil (south-eastern and western parts of the peninsula). They are almost without vegetation, only rare aggregations of annual saltworts can be found there (*Climacoptera aralensis, Halimocnemis sclerosperma, Bienertia cycloptera*). Communities of *Caragana grandiflora* and *Stipa lessingiana* located in ravines of plateau play not big significance in vegetation cover of the original coast. Communities of *Krascheninnikovia ceratoides* and *Salsola arbuscula* are situated in the west coast bordered sand dunes. Meadows with *Aeluropus littoralis*, *Phragmites australis* connected with depression flooded by spring water.

Vegetation of the Aral marine terraces. Origin of terraces is connecting with the Aral Sea transgressions on aeolic processes. Marine terraces are composed by medium – and fine-grain sand developed on Tertiary gypsiferous argil occurred at the depth of 1-1.5 m in a number of cases. Sands are low- and non-saline. Relief is mostly flat with gentle slopes and small hummocks of phytogenic origin, hillock-low-hummocky sand dunes are situated in north-western and north-eastern coasts of the peninsula. Terraces surround former island as a belt from 100-200 to 2000 m width. They are not separated in steep south coast. Saxaul (*Haloxylon aphyllum, H.persicum*) dominates in vegetation cover. Plant communities of *Atraphaxis spinosa, Ephedra distachya, E. intermedia, Calligonum aphyllum, C.caput-medusae, C.macrocarpum, Convolvulus erinaceus, Artemisia arenaria* have less significance. Saxaul communities have coverage from 10 to 70%, floristic composition of them includes more than 30 plant species: *Ephedra distachya, Atraphaxis spinosa, Calligonum aphyllum, Astragalus brachypus, Alhagi pseudalhagi, Salsola paulsenii, Anisantha tectorum, Meniocus linifolius, Alyssum turkestanicum, Eremopyrum orientale, Senecio noeanus, Kochia odonthoptera, Eremopyrum orientale, Aeluropus littoralis*. Saxaul communities grow mostly in eastern and western coasts. Communities of *Atraphaxis spinosa* are marked in northern and western coasts, have coverage 10-25 (50)%, floristic composition of them includes 15 plant species. *Ephedra distachya* communities occur in the northern coast, microcoenoses are marked in all coasts. Vegetation coverage of them 15-25%, floristic composition comprises 14 species. Communities with dominance of *Calligonum* spp. are distributed rarely in the northern and eastern coasts, but everywhere as components of psammophytic plant communities. *Artemisia arenaria* communities are found only in the area of a well (the northern coast), coverage of them is 15-20%, floristic composition includes 9 species. *Tamarix* spp. communities occur in the northern coast. Twenty years ago they characterized by high productivity and coverage of 70-80%. Decreasing of ground water table has caused degradation of them. Communities of *Nitraria schoberi* (Demchenko 1950) had already disappeared. Vegetation of dunes is formed by *Tamarix laxa, T.ramosissima, T.hispida, Haloxylon aphyllum, Calligonum* spp. Coverage in plant communities varies from 15 to 70%, in floristic composition are 15 species (*Stipagrostia pennata, Eremosparton aphyllum, Convolvulus erinaceus, Salsola paulsenii*, etc.). Psammophytic shrubs actively occupies sand dunes while *Tamarix* avandunes are formed in the dry seabed.

Vegetation of the dry seafloor. Dry seafloor is represented by sere of sand beaches corresponding to levels of the Aral Sea desiccation, heterogeneous in ecological conditions. Zone of marsh and coastal solonchaks is characterized by shallow ground water table (40-45 cm). Crust horizon is highly saline (12.95%), salinity is chloride-sulphate of sodium. Underlying horizons are low- and medium-saline. Sands of adjoin to dunes are non-saline; ground water is at a depth of 140 cm.

Northern and north-western coast. Aggregations of *Salicornia europaea* are distributed on marsh and coastal solonchaks. There are 3-4 species in floristic composition (*Salicornia europaea, Tamarix hispida, Suaeda crassifolia, Halocnemum strobilaceum*). Tamarisk occurs as single plants or belts that are fixed by dry Zostera arbor coincided with levels of the sea decreasing. Relief is phytogenic of 30-50 cm height. Vegetation coverage is 25%. Floristic composition consists of 6 species: *Tamarix laxa, Coryspermum hyssopifolium, Phragmites australis, Suaeda crassifolia, Salicornia europaea, Atriplex pratovii.* Desalinization of sand and deflation of surface horizons lead to formation of typical psammophytic communities started from rare aggregation of *Stipagrostis pennata* on hummoks and *Eremosparton aphyllum* in blown depressions. Communities of psammophytic shrubs with coverage of 14-17% have formed on the beach of 1960s. Five plant species (*Eremosparton aphyllum, Astragalus brachypus, Convolvulus erinaceus, Calligonum sp., Salsola paulseni*) represent floristic composition. *Halocnemum strobilaceum* and *Haloxylon aphyllum-Halocnemum strobilaceum* communities are widespread in the northern coast. Vegetation coverage is 25%. Communities of *Alhagi pseudalhagi* with psammophytic shrubs with coverage of 50-55% and floristic composition of 7 species have formed in the beach of 1960s. The western coast is widely vegetated by *Stipagrostis pennata* communities and aggregations. Eastern coast of Barsakelmes island is joined with original coast. The soils of the dry seabed are represented mostly by coastal solonchaks and coastal soils with blown sand cover. Vegetation cover between the island and the original coast consists of aggregation of annual saltworts (*Salicornia europaea, Suaeda acuminata, Bassia hyssopifolia, Petrosimonia triandra, Atriplex pratovii*), sometimes with Tamarix laxa. Barren lands with rare plants (<1%) or without plants occur not infrequently. Occupation by *Salicornia europaea* and *Suaeda acuminata* in some places is connected with spring-summer rainfall and seed banks in a soil. Saxaul communities are particularly widespread nearby the peninsula where often form phylogenic relief, height of hummocks are 50-150 cm. Coverage of vegetation reaches to 40%. There are 5 species in floristic composition: *Haloxylon aphyllum, Salsola paulsenii, Atriplex pratovii, Halostachys belangeriana, Stipagrostis pennata.*

<u>Southern coast</u> adjoin to cliffs of plateau (chinks). The dry seabed are composed by marine deposits of different size - coarse-grained sand and rubble – pebble material. Vegetation cover is formed by communities of *Astragalus brachypus, Phragmites australis, Climacoptera aralenisis, Haloxylon aphyllum* with high coverage (from 30 to 80%) and floristic composition of 3-8 species (*Stipagrostis pennata, Salsola paulsenii, S.foliosa, Alhagi pseudalhagi, Senecio noeanus, Atriplex pratovii, A.aucheri, Descurainia sophia*).

Vegetation cover of Barsakelmes island underwent grate changes since time of decreasing of the Aral Sea level. Salt lagoons of the western and northern coasts dried up at the first time of transformation of ecosystems in 1960s. Lakes' shores once vegetated by meadow-halophytic forbs (*Phragmites australis, Typha laxmannii, Karelinia caspia, Calamagrostis epigeios, Aeluropus littoralis*) (Demchenko, 1950) changed into solonchaks with *Halocnemum strobilaceum* and *Limonium suffruticosum*.

Grate changes has affected saxaul vegetation. Saxaul woodlands of the State reserve are unique natural ecosystems for all the Aral Sea area. Formation of saxaul communities is connected with shoreline sands. In the area of plateau saxaul does not form communities, sometimes it play sub-dominant role in sagebrush communities. Such landscape looks like savanna. Aggregations of saxaul can be seen in ravines of Segizsay area and along shoreline of the southern coast. Saxaul woodlands repeatedly had been disforested. Wood and charcoal of saxaul had collected from the island in the end of the XIX-beginning of XX centuries. Protected regime gave possibility for restoration of woodlands. However there are new problems at present time. After unification of Barsakelmes island with the eastern coast wild animals migrated into the original coast. Grazing has stopped. Inspection of saxaul communities has shown disturbance of self-regeneration in some parts as a result of insufficient grazing and connected with spreading of desert moss *Tortula desertorm*. Several communities of *Haloxylon aphyllum* were described.

Ephedra distachya - Haloxylon aphyllum community is described in the Aral marine terrace of the northern coast. Relief is hummocky, cryptogam cover of desert moss up to 90%. Coverage of vegetation is 40-43%. Floristic composition is 12 species: *Haloxylon aphyllum* – 15%, *Ephedra distachya* – 20%, *Atraphaxis spinosa* – 5-7%, *Calligonum aphyllum* – 1%, *Astragalus brachypus* - <1%, *Alhagi pseudalhagi* - <1%, *Salsola paulsenii* - <1%, *Anisantha tectorum* -<1%, *Meniocus linifolius* - <1%, *Alyssum turkestanicum* - <1%, *Eremopyrum orientale* - <1%, *Senecio noeanus* - <1%.

Haloxylon aphyllum community is described in the Aral marine terrace of the north-eastern coast. Fine-grained sand surface is covered by litter, shells, cryptogam cover 3-5%. Coverage of vegetation is 50-60%. Floristic composition is 9 species: *Haloxylon aphyllum* – 40%, *Ephedra distachya* – 3-5%, *Kochia odontoptera* – 3-5%, *Senecio noeanus* – 1%, *Eremopyrum orientale* - <1%, *Anisantha tectorum* - <1%, *Aeluropus littoralis* – 3%, *Lepidium perfoliatum* - <1%, *Atraphaxis spinosa* – 1-3%.

Atraphaxis spinosa - Haloxylon aphyllum community is described in the Aral marine terrace of the north-western coast. Gently dipping marine plain. Coarse-grained sand and rubble are in the surface. Moss covers from 50 to 90% of the surface. Coverage of vegetation is 60%. Floristic composition is 7 species: *Haloxylon aphyllum* – 40%, *Atraphaxis spinosa* – 20%, *Ephedra distachya* - <1%, *Anisantha tectorum* - <1%, *Meniocus linifolius* - <1%, *Strigosella circinata* - <1%, *Senecio noeanus* - <1%. Vitality of saxaul is satisfactory and bad. Height of saxaul varies from 100 to 200 cm. Plot of 100 sq m consist of 15 living depressed, 8 dry saxaul plants and 11 *Atraphaxis* plants. All plants are old.

Haloxylon aphyllum community is described in the north-western coast between the Aral marine terrace and undulating plain. It is a dry bed of existed salt lake. There are polygonal cracks in the surface. Crust and underlying horizon have loam soil texture. Lower horizons are coarse-grained sand. Coverage of vegetation is 25-30%. Floristic composition is

2 species: *Haloxylon aphyllum* - 25-30%, *Ephedra distachya* - <1%. The age of saxaul is from 10 to 20 years old. The most of plants are dry, the rest are in depressed condition with rare assimilation shoots. Degradation of the community is natural connected with decreasing of ground water table.

As a result of inspection it was discovered that the part of saxaul woodlands of original coast have been degrading. High vegetation coverage leads to insufficient water supply. Despite of high seed productivity there are no any seedlings and young plants in communities. The none-disturbed cover of desert moss is the main competitor of seedlings and ephemerals for using of spring precipitation. Decreasing of the ground water table connecting with desiccation of the Aral Sea is the other reason of degradation of saxaul woodlands. They were formed in the western and north-eastern coasts at the places of dried up lagoons in 1960s. Decreasing of ground water table was gradual. Lack of moisture had been expressed by early appearance of autumn yellow colour of assimilative shoots than in other habitats. 70% of these woodlands have dried up last time. Active formation of saxaul communities has been continuing in the dry seabed on the other hand. They had been occurred only in the northern coast in 1980s, nowadays saxaul spreads everywhere. The first stage of primary succession 20 years ago had started from orach (*Atriplex pratovii*) aggregations and communities and continued for 3-7 years, after that perennial grass and saltwort (*Stipagrostis pennata, Halocnemum strobilaceum*) had colonized the territory. Another species (*Salicornia europaea, Suaeda acuminata, S.crassifolia*) occupy a primary marine surface now that is caused by increasing of a sea water mineralization.

Thus, vegetation cover of Barsakelmes peninsula reflects all botanical diversity of the Aral Sea deserts (in the limits of Kazakhstan). Zonal vegetation of plateau – *Anabasis salsa – Artemisia terrae-albae* complex – is similar to floristic composition and structure of plant communities of North Aral region. The basis for this is commonness of geological history of the island and the northern coast. Vegetation of a steep southern coast is analogous to the north-western bays of the Aral Sea with cliffs (Dimeyeva 2004). Similar species (*Amberboa turanica, Artemisia aralensis, Fumaria vaillantii, Ferula canescens*) occupy steep slopes and ravines. Psammophytic vegetation of Aral marine terraces has similarity with East Aral region. Penetration of psammophytic species (*Calligonum* spp., *Haloxylon persicum, Ammodendron conollyi, Astragalus brachypus*) into the island took place during regressive stages of the Aral Sea through land bridges between the eastern coast of Barsakelmes and mainland (as at present time). Stems of saxaul found in marine sediments lower then former sea level by 16 m illustrate the existence of regressions in ancient time (Eliseyev 1991).

2.4.2.2. VEGETATION OF KASKAKULAN AREA. Phytocoenotic biodiversity is characterized by unique combination of plant populations of different life forms, strategies and diversity of communities and aggregations being formed in different stages of primary succession. Vegetation of Kaskakulan island is represented by communities of sagebrush with ephemeroids (*Artemisia terrae-albae, Tulipa biflora, T.borszczovii, Scorzonera pusilla, Poa bulbosa*), saxaul woodlands (*Haloxylon aphyllum, H.persicum*) and dwarf semishrub saltwort (*Halocnemum strobilaceum*). Nearby wells there is meadow vegetation with *Phragmites australis, Saussurea salsa, Atriplex littoralis*.

Vegetation of the dry sea floor is formed under the influence of arid climate on marine deposits of light texture (sand, loam). Vegetation cover of the dry seabed bordering to the eastern original coast mostly consists of communities of perennial and annual chenopods (*Anabasis aphylla, Kalidium caspicum, Nitraria schoberi, Haloxylon aphyllum, Climacoptera aralensis, C.ferganica*) of 15-50% coverage on takyr-like soils with ground water table at the 4 m depth. Takyr-like solonchaks with ground water table lower then 3 m are occupied by *Climacoptera aralensis – Kalidium capsicum, Halocnemum strobilaceum - Kalidium capsicum, Kalidium capsicum- Halocnemum strobilaceum* communities. The dry seabed between the island and the eastern coast is vegetated by *Halocnemum strobilaceum, Kalidium capsicum, Suaeda microphylla* communities on coastal soils with blown sand cover and crust-puffed solonchaks of loam texture. There are 5-7 species in plant communities with coverage of 30-70%. Saxaul communities (*Haloxylon aphyllum*) widespread in the areas close to the island on coastal soils with blown sand cover. *Halocnemum strobilaceum, C.aralensis, Salsola nitraria, K.caspicum, Halostachys belangeriana* - are sub-dominants in them. Plant communities consist of 5-8 species with high coverage (40-80%). The dry seabed between islands Kaskakulan and Uzunkair is composed by sand sediments that is why aeolic forms of relief is widespread there. *Atriplex pratovii, Coryspermum aralo-caspicum, Eremosparton aphyllum, Stipagrostis pennata* species occupy hummocky sands. Deflation basins and sand plains are vegetated by *Astragalus brachypus, Halocnemum strobilaceum, Alhagi pseudalhagi* (floristic composition is 5-9 species, coverage is 30-40%). *Tamarix* spp. and *Nitraria schoberi* form phytogenic hummocks. Communities of *Haloxylon aphyllum, Krascheninnikovia ceratoides, Halocnemum strobilaceum, Salsola nitraria, Zygophyllum oxianum* and microcoenoses of *Limonium otolepis* occupy the area nearby Uzunkair island. Psammophytic-shrub vegetation (*Astragalus brachypus, Calligonum* spp., *Convolvulus erinaceus*) is distributed in the island in combination with *Tamarix hispida* phytogenic hummocks. Vegetation cover in the dry sea floor between Uzunkair and Barsakelmes island is very rare, coverage is not more then 5-7%, Seldom plants and aggregations of *Tamarix laxa, Atriplex pratovii*, sometimes *Haloxylon aphyllum* and lands without any plants are occupy this area. Coastal solonchaks of heavy texture are widespread, they are gradually covering by thin sand layer blown from Uzunkair colonized by orach.

2.5. Fauna

The Aral Sea region is internationally recognized as a priority area for wetland conservation. The Aral Sea lies within one of the most important North-South flyways of Palaearctic migrants with the Central Asian - Indian Flyway and East African Flyway converging over this region. The delta lakes and shorelines provided significant foraging and breeding habitats for large numbers of waterfowl (ducks, geese) and other water birds (pelicans, cormorants, herons, plovers, terns, gulls). Thirty bird species are listed to the Red Book. However, avifauna in and around the Aral Sea and in the delta is still spectacular. Drastic changes in the fauna spectrum of the Aral Sea have occurred since the 1960s. So far, very few species have permanently occupied the new, exposed lands. Some 67 mammal species have been recorded along the Syr Darya (including 30 near the North Aral Sea). Sixteen species are listed in the Red Data. Book. Besides, many animals are economically or commercially significant. Most species are typical of the desert environments (Bekenov A., Kovshar A., Jashenko R., 1998).

Invertebrates. There are approximately 2095 species from 12 orders of insects were in the Aral Sea region: Odonata (13), Mantoptera (3), Blattoptera (2), Phasmoptera (1), Dermaptera (2), Orthoptera (90), Homoptera (520), Heteroptera (125), Coleoptera (731), Lepidoptera (60), Hymenoptera (248), Diptera (300). The most numerous insects are beetles (Table 2). Information about 18 other orders, inhabiting the Turan deserts, is absent (Kazenas et al., 1998.). Besides species diversity, the level of endemism is an important index of originality. There are 121 aralian endemic species, which is 5.8% of all known species. This percentage will grow through future research, discovering new local species. For example, the percentage of endemic species of the well-studied Coccinea (Homoptera) and Cecidomiyidae (Diptera) is 35% and 22%, respectively (Jashenko, 1993; Fedotova, 1993). Biological and ecological features of endemic species remain to be studied. These autochton species are promising subjects for monitoring. Rare and vanishing species are two special categories of regional fauna. Twenty seven rare species from the Red Data Book of Kazakhstan (1991) dwell in the northern Aral Sea region. Table 3 shows habitats of these species. More species should be added to the Red Data Book, e. g. Aromia moschata ssp. vetusta Jank. (Coleoptera, Cerambycidae) and Eurythyraea oxyana Sem. (Coleoptera, Buprestidae), which have not been reported in the river-bed forests of the Syrdarya for twenty years. Current investigations shows considerable increase of species diversity of zooplankton in comparison with critical period in the 1980th. 88 taxa of microcrustacea were identified, 55 species and subspecies from them belongs to Cladocera, 32 species to Copepoda (2-Calanoida, 24-Cyclopoid, 6-Harpacticoida) and Ostracoda. Fauna of Rotifera consists of 73 species. Also, Bivalvia mollusc larvae were revealed in two waterbodies.

Table 2. Families of Coleoptera on the Northern coast of the Aral Sea

Families	Total number of species	Species endemic to the Aral Sea area	Rare and relic species
1. Carabidae	150	2	1
2. Histeridae	34	3	-
3. Scarabaeidae	125	13	1
4. Cerambycidae	21	5	2
5. Buprestidae	39	4	2
6. Coccinelidae	41	-	1
7. Meloidae	22	3	-
8. Chrysomelidae	130	-	-
9. Curculionidae(Cleoninae)	62	1	-
10. Tenebrionidae	85	4	-
11. Elateridae	4	-	-
12. Anobidae	5	-	-
13. Other families	13	-	-
Total	731	35	7

Table 3. Distribution of rare and vanishing species in natural locations of the Northern Aral Sea region

Species	gallery forest	sea coast	sand desert	clay desert	salt-marsh	chink
1. *Ischnura aralensis* Hant	+	-		-	-	-
2. *Caloptex virgo* L.	+	+?	-	-	-	-
3. *Anax imperator* Leach.	+	+	-	-	-	-
4. *Orthetrum sabina* Drury	+	-	-	-	-	-
5. *Selycsio themis nigra* V.	+	-	-	-	-	-
6. *Bolivaria brachiptera* Pall.	+	+	-	+?	+?	+
7. *Saga pedo* Pall.	+	+	-	-	-	+
8. *Seraeocercus fuscipennis* Uv.	+	-	-	-	-	+
9. *Cicindela nox* Sem.	+?	-		-	-	-
10. *Calosoma sycophantha* L.	+	-	-	-	-	-
11. *Haplosoma ordinatum* Sem.	+	+?	+	-	-	-
12. *Stethorus punctillum* Weise.	+	+	-	-	-	-
13. *Scolia hirta* Schr.	+	+	+	+	-	+
14. *Sphex flavipennis* Fabr.	-	+	+	+	+	+
15. *Prionix macula lugens* Kohl.	+	-	+	+	+	-
16. *Hoplitis megalosmia fulva* Evers.	+	-	+	-	-	-
17. *Ephedromya debilopalpis* Marik.	+?		-		-	-
18. *Satans gigas* Evers.	+	+	+	-	-	+
19. *Ascalaphus macaronius* Scop.	+?	-	-	-	-	-
20. *Zigaena turcmena* Evers.	+		-		-	-
21. *Utetheisa pulchella* L.	+	+		-	-	-
22. *Paragluphisia oxiana* Djak.	+	-	-	-	+?	-
23. *Catocala optima* Stgr.	+	-	-	-	-	-
24. *Papilio machaon* L.	+	+	+	+	-	-
25. *Zegris eupheme* Esper.	+	+?	-	+?	-	-
26. *Microzegris pyrotoe* Evers.	+	+?	+?	-	+?	-
27. *Polyommatus elvira* Evers.	+	-	-	-	-	-
28. *Hesperophanes heydeni* Ball.	-	-	-	-	+	-
29. *Capnodis miliaris metallica* Ball.	+	-	-	+	+	-
Total	27	13	8	8	7	9
%	90.3	44.8	27.6	27.6	24.1	30.1

Vertebrates. Before the beginning of the Aral Sea catastrophe, the vast desert expanses of the North and East Aral Sea region including Aktobe, Kyzylorda and the western part of South Kazakhstan Provinces were inhabited by more than 300 species of vertebrate terrestrial animals. 30% of Kazakhstan mammals were found here, together with 41% of nesting birds and 59% of reptiles, while the local class representation of the desert zone fauna of Kazakhstan were as follows: 79% mammals, 88% reptiles and 95% birds.

The waters of the Aral Sea basin were inhabited by more than 40 fish species, among them such unique and endemic ones as Syrdarya Shovelnose (*Pseudoscaphirhynchus fedtschekoi*) Bastard Sturgeon (*Acipenser nudiventris*), Aral Trout (*Salmo trutta aralensis*), and Pike Asp (*Aspiolucius esocinus*); numerous colonies of pelicans (*Pelecanus onocrotalus, P.crisous*), cormorants (*Phalacrocorax carbo, P. pygmaeus*), geese, swans, a great number of ducks, herons, gulls, plovers and other bird species were on the islands and shores; wild boar (*Sus scrofa*) were very abundant in the riparian brushwood along Syrdarya River; even the Turanian Tiger (*Panthera tigris virgata*) occurred in this river delta, while adjacent desert sites were inhabited by Saiga (Saiga tatarica) and Persian Gazelle (*Gazella subgutturosa*); Macqueen Bustards (*Chlamydotis undulata*), Sandgrouse (*Pterocles orientalis, P. alchate, Syrrhaptes paradoxus*), were also abundant here.

As a result of the negative influence of intensive development in economic activity, accompanied by the sharp drop in regional water supply and the development of local desertification processes, during the second half of the 20th century the biodiversity of e.g. nesting birds has half decreased while the ichthyofauna has lost its most interesting, endemic and relict representatives. Many animal species no longer occur in the region: it has been confirmed by the large number of local rare and vanishing species included in the Kazakhstan Red Data Book (1996), among them 6 fish species (37.7% of the total included in the Red Data Book), 2 reptile species (20.0%), 27 bird species (48.2%), 11 mammal species (27.5%). More than half of those (27 species or 58.7%) belong to the first two status categories, the most endangered ones: 1. Vanishing species (including presumably deleted ones), and 2. Species of rapidly decreasing abundance.

The fish fauna of the North Aral Sea is formed by two ecologically different fish groups (Mitrofanov, 1996): (i) introduced flounder; and (ii) small-sized species of salt-tolerant freshwater fish species, that are no longer of commercial importance because of increased salinity levels. Some 14 species have been introduced in the Aral Sea after it salinity levels started rising, only the flounder survives. At present, three fish species are included in the Red Book. The delta lakes and river flood plain play an important role as spawning and nurturing sites for many original river and sea species. Lake fisheries, however, declined for a number of well-known reasons: increasing salinity, lack of replenishment of freshwater, blocked access to the lakes and floodplains (catfish) and drying up of lakes. It is known that, before the construction of water regulatory works in the Syrdarya , many of the indigenous fish species migrated up to 600 km upstream. The present spawning area is limited by the Kazalinsk hydraulic system (200 Ian upstream) and fish also use for spawning the area bordered by the temporary Aklak dike some 30 km from the sea. The potential impacts of the proposed Aklak hydraulic structure on fish migration have been carefully taken into account in the design and location of this structure.

According to research provided by I. Mitrofanov, N. Mamilov and V. Skakun (2002) the species distribution of fishes in north and south part of Small Aral Sea was very different. In the north only six species were found. Five of them are marine exotic species. Four were introduce occasionally from the Caspian Sea and one – flounder (*Pl. flessus luscus*) was introduced from Black Sea as a substitution of nature species. Three gobies species are now rare and only a few specimens were found. These species – bubyr (*Knipowitschia caucasica*), monkey goby (*Neogobius fluviatilis*), round goby (*Neogobius melanostomus*) are euryhaline and very abundant in the Caspian Sea – the motherland waterbody and could habitat in fresh water of river deltas and in bays with salinity over 30‰. The dominant species was sand-smelt (*Atherina boyeri*) – exotic species from Caspian Sea. The only carp native species was found only once – it was a small sabrefish (*Pelecus cultratus*). It is evidence that North part of the Small Aral Sea now habitat with marine fish only. Two species could be fishing – flounder and sand-smelt. Both are numerous, but their size is small. In the south part near to Syrdaria mouth six native species were found. All of them are fresh water fishes and use maritime area only as a feeding ground. There were no seining, that's why no sand-smelt were caught, but no doubts it was numerous here too. The species diversity of the south part of the Sea was similar to species composition of Syrdaria river. In the river thirteen species were found, twelve of them were native and only one – silver carp (*Hypophthalmichthys molitrix*) was exotic. Eleven species were different carp-like fishes, one was perch-like fish – sander and one catfish. All these species could be fishing. There were several really valuable species – carp, sabrefish, catfish, asp, bream, roach. All of them were fishing commercially before. Now only carp is fishing in commercial amount by several local groups of fishermen. Species composition in the Kamyshlybash Lake is similar to the river, but had some peculiarity. Only eight species were found here, and sand-smelt was very numerous. Also the goby species – bubyr – was found. These two species was not found in the river. There were no riverine species in the lake such as dace and asp. On the other hand two species were found only in lake, but not in the river. It was perch (*Perca fliviatilis*) and pike (*Esox lucius*). Both are strictly fresh water piscevores.

There is no doubts that river and lake are the refugium of all fresh water fishes in the region. In case of desalinization of Small Aral Sea several fish species from river and lake could found good feeding ground in the sea area around delta as carp do it now. Their number could be increased and fishing would became commercially valuable. The most important species are carp, bream, roach, and sander.

Altogether in the north half of Aral Sea 126 bird species are recorded 88 of which nest there while the remainder migrate; 70 species of the total were observed in the North Aral Sea area 61 of which nest there; the corresponding indices in the East Aral Sea area are 106 (66) (Tab. 4.).

Table 4. Fauna comparison of birds in different part of Aral sea (in brackets are breeding birds)

Bird orders	Species number in:						
	eastern coast		northern coast		new lands		Total
	abs.	%	abs.	%	abs.	%	species
Ciconiiformes	1(1)	0.9	2	2.9	-	0.0	3
Anseriformes	8(4)	7.5	2(2)	2.9	2	11.1	8
Falconiformes	7(4)	6.7	7(4)	10.0	1	5.6	10
Gruiformes	2(1)	1.9	1(1)	1.4	-	0.0	3
Charadriiformes	22(8)	20.7	7(7)	10.0	4(3)	22.2	22
Columbiformes	7(7)	6.7	7(6)	10.0	3(2)	16.7	8
Cuculiformes	1(1)	0.9	1	1.4	-	0.0	1
Strigiformes	2(1)	1.9	1(1)	1.4	-	0.0	2
Caprimulgiformes	1(1)	0.9	1(1)	1.4	-	0.0	1
Apodiformes	1(1)	0.9	1(1)	1.4	-	0.0	1
Coraciiformes	4(4)	3.8	4(4)	5.8	-	0.0	5
Passeriformes	50(36)	47.2	36(35)	51.4	8(4)	44.4	62
Total	106(69)	100,0	70(62)	100,0	18(11)	100,0	126

2.6. Chemical pollution

Distribution of chemical pollutants. Toxicological studying in distribution of chemical pollutants in hydrosystems of North part Aral sea shows the presence of HM and COP in water, bottom sediments, macrophytes, water invertebrates, fish tissues, agricultural crops, meat of domestic animals. The macrophytes, living in the delta lakes, can be used as a detoxicant in biological purification of small lakes. The content of COP exceeds the SSI indices in the majority of samples. It can be the reason of some human diseases in this area. Observation shows the necessity of permanent monitoring research in Syrdarya delta area. The analyse of water samples in summer 1997 showed the rather mosaic picture of HM distribution in water areas of Syrdarya delta (Table 5). The contents of HM in delta lakes, river and Aral Sea were as follow: Zn 23.30 -108.17 μg/l; Cu 48.20 - 101.31 μg/l; Cd 0.31 - 2.52 μg/l; Pb 25.90 - 91.89 μg/l. The most polluted lakes are Kotankol lake (Akshalan lake system), Kartma lake (environs Karateren Village), Tuschebas lake (right coast of Syrdarya River) and Laykol lake (Kamyshlybash lake system). Cu, Zn and Pb prevail in the water. Kamyshlybash Lake contains the minimum quantity of Zn and Cu, but Laykol Lake has more high concentration of these elements. The content of HM in a river water is lower: Zn - 38.76 μg/l, Cu - 66.25 μg/l, Cd - 0.31 μg/l, Pb - 25.99 μg/l.

The increase of the HM content was observed in the delta lakes in summer 1998. In Karashalan lake system: Zn - 42.5 μg/l, Cu - 76.8 μg/l, Pb - 28.11 μg/l. The Pb content in Kamyshlybash system was decreased in 2 times - till 41.75 μg/l. The concentration of Cu and Pb in the water of Syrdarya was decreased in 2 times, but indices on Zn were stable in river water as well as in Small Aral Sea. The gradual lowering of the Cu and Pb content continued in the water of delta lakes in summer 1999. Concentration levels of Cd and Zn were stable and equal to the indices of 1998. So, according to monitoring water research of the delta lake system of Syrdarya River the indices of Cu and Pb are decreasing, but Zn and Cd are in high stable level. The research of the toxicological situation of Chardara reservoir (middle part of Syrdarya River) showed the presence of COP in the water in 1992-96, the content of hexachlorane in that time was 20-160 ng/l. The studying of COP pollution in the Syrdarya river and delta lakes in 1997 showed the high content of toxicants (Table 6); concentration of HCCH, including its isomers, was up to 0.05 μg/l in river water. The level of water pollution by HCCH isomers was increased along to river flow from Kazalinsk City to the river outfall. DDT pollution was decreased on the contrary. The content of the HCCH isomers in Aral Sea was not more than 0.015 μg/l, DDT – 0.016 μg/l, DDE – 0.180 μg/l. In 1998 the levels of water pollution by COP in delta lakes were: α-HCCH 0.015 - 0.044 μg/l, γ-HCCH 0.002 - 0.016 μg/l, DDT 0.012 - 0.035 μg/l, DDE 0.120 - 0.402 μg/l. There was some increase of the content of α-HCCH and DDE in the river water near Kazalinsk City and DDT in the river outfall. The stable high level of α-HCCH (0.056 μg/l) was observed in the Karashalan lake. In general, the COP content in the river and delta lake water continued to decrease.

The lake grounds in Syrdarya delta are presented by silt sands with impregnation of the detritus rests and other admixtures. The analyse of the HM concentrations in bottom sediments showed the stable situation on the comparison with water pollution. In 1997 the HM accumulation was as follows: Zn 7.02 - 17.54 mg/kg; Cu 6.30 - 40.97 mg/kg; Cd 0.24 - 0.58 mg/kg; Pb 6.50 - 16.24 mg/kg. Maximum metal concentration was observed in the sediments of Kartma Lake, the high HM pollution was in Syr-Darya, the highest indices were on Cu and Zn. Tuschebas Lake has also the high indices of HM: Cu – 30 mg/kg, Zn – 16.6 mg/kg and Pb – 12.0 mg/kg as well as Kamyshlybash Lakes: Zn - 15.0 mg/kg, Cu - 12.7 mg/kg, Cd - 0.31 mg/kg, Pb - 6.5 mg/kg. The lowest concentrations were observed in Small Aral Sea and Aschikol Lake, the contents of Cu, Pb and Zn were up to 5.0-8.0 mg/kg.

The HM content in the bottom sediments in the summer 1998 varied as follow: Zn - 7.02 - 17.65 mg/kg; Cu 5.94 - 17.08 mg/kg; Cd 0.21 - 0.55 mg/kg; Pb 6.18 - 15.76 mg/kg; the maximum indices were in the lakes of Tuschebas and Kamyshlybash system. At the same time, the high concentrations of Zn, Cu and Pb were discovered in the river sediments; there were Zn – 17.65 mg/kg, Pb - 15.76 mg/kg, Cu – 17.08 mg/kg. In summer 1999 (Table 3) the Pb concentration decreased till 11.34 mg/kg in the silts of delta, other element indices were on the level of 1998.

Table 5. Concentration of HM in the components of hydrocoenoses of Syrdarya delta area.

Research objects	Ingredients µg/l, mg/kg			
	Zn	*Cu*	*Cd*	Pb
Water				
Syrdarya river (Kazalinsk City)	38.76	66.25	0.31	25.99
Small Aral Sea	52.63	80.01	0.35	98.24
Kamyshlybash Lake	39.10	81.30	0.97	91.89
Laykol Lake	44.27	90.03	0.50	51.98
Utebas Lake	23.30	68.60	1.09	88.60
Karashalan Lake	62.21	108.75	0.73	58.47
Kartma Lake	108.17	48.20	0.98	84.46
Kotaykol Lake	90.04	63.10	1.39	29.94
Aschikol Lake	65.31	98.21	1.61	55.96
Big Aral Sea	53.61	95.29	2.52	63.48
Ground				
Syrdarya river (Kazalinsk City)	17.54	40.97	0.32	15.59
Small Aral Sea	5.85	6.30	0.30	3.90
Kamyshlybash Lake	15.09	12.73	0.31	6.50
Utebas Lake	10.88	16.97	0.41	8.12
Karashalan Lake	7.02	6.42	0.24	4.22
Kartma Lake	16.49	38.06	0.58	16.24
Kotaykol Lake	12.51	18.55	0.55	8.77
Tuschebas Lake	16.60	34.91	0.50	12.02
Macrophytes				
Typha (Syrdarya river)	10.99	13.21	0.16	1.95
Typha (Aschikol Lake)	7.02	6.79	0.16	1.62
Typha (Kotaykol Lake)	11.46	13.94	0.17	1.95
Potamogeton filiformis (Karashalan Lake)	20.47	15.52	0.58	10.07
Potamogeton filiformis (Kamyshlybash Lake)	8.78	10.30	0.41	5.85
Chara (Tuschebas Lake)	8.42	32.12	0.72	12.67
Chara (Laykol Lake)	14.85	33.70	0.77	13.97
Filamentous alga (Aral Sea)	19.76	22.18	0.60	9.75
Zooplankton				
Kamyshlybash Lake (*Cladocera*)	7.26	2.63	0.34	3.21
Karashalan Lake (*Cladocera*)	6.34	2.56	0.65	3.44
Zoobenthos				
Kamyshlybash Lake (molluscs)	25.14	7.86	1.74	4.30
Karashalan Lake (*Chironomidae* larvae)	15.36	4.12	1.08	3.71
Fishes in Kamyshlybash Lake*				
Cyprinus carpio	19.34/34.15	4.58/10.17	1.15/2.05	1.14/4.56
Silurus glanis	14.56/29.46	5.11/12.34	1.05/1.96	0.96/2.98
Esox lucius	11.18/19.17	3.64/11.07	1.21/1.545	0.84/1.76
Aspius aspius	14.15/21.23	3.76/132.04	0.96/1.42	0.76/2.05
Rutilus rutilus	15.11/36.11	4.12/17.11	1.03/1.95	0.93/2.34

* Numerator – muscles, denominator - liver

Table 6. Content of persistent pesticides in the components of hydrocoenoses of Syrdarya delta

N	Research objects	HCCH isomers		DDT metabolits	
		α	γ	DDT	DDE
		Water, μg/l			
1	Syrdarya	0.044	0.003	0.021	0.240
2	Small Aral Sea	0.015	0.001	0.016	0.180
3	Aschikol Lake	0.050	non-detected	0.029	0.150
4	Kotankol Lake	0.020	0.020	0.010	0.170
5	Kartma Lake	0.021	0.014	0.010	0.043
6	Karashalan Lake	0.055	0.016	0.020	0.190
7	Tuschebas Lake	0.034	0.020	0.014	0.310
8	Laykol Lake	0.022	0.019	0.020	0.260
9	Kamyshlybash Lake	0.015	0.002	0.012	0.130
10	Utebas Lake	0.040	non-detected	0.030	0.210
		Ground, μg/kg			
11	Syr-Darya	1.10	0.14	4.70	7.10
12	Small Aral Sea	3.00	1.20	1.70	4.10
13	Aschikol Lake	2.00	0.20	1.90	3.90
14	Kotankol Lake	1.40	0.40	2.40	3.00
15	Kartma Lake	1.70	0.10	3.00	2.40
16	Karashalan Lake	0.90	non-detected	2.70	6.10
17	Tuschebas Lake	4.80	2.90	5.00	9.20
18	Kamyshlybash Lake	0.70	0.52	3.50	5.80
19	Utebas Lake	non-detected	non-detected	1.00	4.40
		Macrophytes, μg/kg			
22	*Typha* (Laykol Lake)	13.10	8.70	4.20	3.00
23	*Typha* (Laykol Lake)	10.70	6.50	6.60	5.80
24	*Typha* (Kamyshlybash Lake)	14.00	0.20	1.90	3.50
25	Filamentous alga (Utebas Lake)	9.10	non-detected	5.30	1.10
26	*Typha* (Utebas Lake)	8.30	4.10	5.40	3.70
27	*Potamogeton filiformis* (Utebas Lake)	2.20	7.90	1.10	2.70
28	*Chara* (Tuschebas Lake)	7.30	2.80	1.60	8.40
29	*Chara* (Kartma Lake)	9.70	6.40	1.50	3.20
30	*Potamogeton filiformis* (Laykol Lake)	10.40	3.30	1.00	0.00
31	*Chara* (Laykol Lake)	8.10	6.80	1.90	3.90
		Zooplankton (Kamyshlybash Lake), μg/kg			
32	*Cladocera*	1.25	1.05	5.60	3.17
		Zoobenthos (Kamyshlybash Lake), μg/kg			
33	*Decapoda*	30.00	15.34	36.65	25.46
34	Mysidacea	17.64	11.11	24.31	29.13
35	*Hironomidae* larvae	7.65	5.84	14.76	48.13
36	Molluscs	25.36	13.87	21.04	40.86
		Fishes *, μg/kg			
37	Cyprinus carpio	19.41/51.46	13.04/19.05	45.16/63.11	26.14/76.08
38	*Silurus glanis*	14.15/69,34	9.12/21.06	29.17/56.08	19.15/70.11
39	*Esox lucius*	26.14/50.16	15.82/29.16	21.13/54.12	15.09/65.06
40	*Aspius aspius*	23.01/59.08	18.46/25.11	15.06/65.11	13.04/51.03
41	*Rutilus rutilus*	17.65/56.14	14.86/23.08	39.73/70.13	22.69/59.13

* Numerator – muscles, denominator - liver

The COP pollution of the bottom grounds in 1997-1999 were rather same on each year: α HCCH (rests - 0.480 μg/kg), γ HCCH (rests - 0.290 μg/kg), DDT (0.100 - 0.500 μg/kg), DDE (0.300 - 0.920 μg/kg). The equal levels of pesticide pollution are in all water system of delta; maximum concentrations were observed in the bottom silts in Kamyshlybash and Tuschebas lakes.

The water plants are the active components of the water ecosystems and concentration of toxicants are very different in some plants. The maximum concentrations are observed in underwater macrophytes with swimming leafs. The species of littoral plants accumulate toxicants less. In 1997 the summer samples of macrophytes in delta Syrdarya showed rather big dispersion in toxicant concentrations. The Potamogeton spp. had the high concentrations of HM in Karashalan lake as follow: Zn - 20.47 mg/kg; Cu - 15.5 mg/kg; Cd - 0.58 mg/kg; Pb -10.0 mg/kg. Filamentous alga from Small Aral Sea had a high content of Zn - 9.7 mg/kg; Cu - 22.1 mg/kg; Cd - 0.6 mg/kg; Pb - 9.7 mg/kg as well as Chara from Laykol lake: Zn - 14.8 mg/kg; Cu - 33.7 mg/kg; Cd - 0.77 mg/kg; Pb - 13.97 mg/kg; and Typha in Kotankol lake: Zn – 11.4 mg/kg and Cu – 13.9 mg/kg. All species of macrophytes, studied in summer 1997-1999 in Kamyshlybash lakes, contained COP and HM. There were Zn 7.02 - 20.47 mg/kg, Cu 6.79 - 33.70 mg/kg, Cd - 0.16 - 0.77 mg/kg, Pb - 1.62 - 13.97 mg/kg. In 1998 the vegetated plants in Kamyshlybash and Tuschebas lake system had the follow HM concentrations: Zn 5.07 - 9.56 mg/kg, Cu - 5.01 - 18.16 mg/kg, Cd - 0.19 - 0.71 mg/kg, Pb - 2.12 - 18.16 mg/kg. The highest concentrations were observed in Potamogeton, Chara and Myriophyllum. The general lowering of HM content was observed in summer 1999 in macrophytes of delta lakes. The maximum concentrations of Zn and Cu were in Potamogeton (8.11 and 12.6 mg/kg correspondingly), the content of Pb and Cd was equal. Chara algae had higher concentration of Cd (0.64 mg/kg). In general, there is a tendency of lowering the concentrations of HM in macrophytes in delta.

Delta water plants had HCCH 10.7-14.1 μg/kg and DDT up to 18.4 μg/kg of damp mass in 1997. Later, in 1998-1999 the pollution level of pesticides was decreased in macrophytes., the maximum concentrations were only for α HCCH – up to 2.26 μg/kg and γ HCCH up to 0.78 μg/kg of damp mass. The level of HM and COP pollution of vegetated plants depended of bottom sediments. The water areas with black oily silts in the lower part of delta had the high content Pb, Cd and COP in plants. On other hand, water areas with grey sandy silts showed the high accumulation of Zn, Cu and less pesticide content in water plants. In general, there is a high possibility of macrophytes for accumulation of toxicants in Syrdarya delta, but there is a tendency of lowering the COP and HM from 1997 to 1999.

This peculiarity of macrophytes can be used for water area clearance from the toxicants with further utilisation of plant biomass. The small lake in the low part of delta (20 hectares, 1.0-1.5 m depth) was chosen as a testing area for this observation. This lake during long time was waterless, but in 1997 it was flooded by Syrdarya water. The macrophytes grew intensively during next 3 years. Analyse of lake water in 1997 showed the same pollutant concentration with river water: Zn - 35.61 μg/l, Cu 46.08 μg/l, Cd 0.31 μg/l, Pb 20.76 μg/l, COP - 0.04 μg/l. In 1998, in time of macrophyte vegetation the concentrations of toxicants in the water were increased: Zn - 21.08 μg/l, Cu - 30.56 μg/l, Cd - 0.21 μg/l, Pb - 10.14 μg/l, COP - 0.02 μg/l. On the contrary, macrophyte samples showed the high pollution level – in 1998: Zn 7.96 μg/l, Cu 15.0-9 μg/l, Cd 0.53 μg/l, Pb 8.36 μg/l, COP - 2.05 μg/l. The levels of toxicants in the lake water samples were less than in water of Syrdarya in 1999, but pollution of macrophytes was stable. It shows the most part of toxicants was withdrawn from the lake water and accumulated in macrophytes. In summer 1999 the content of toxicants in lake water was decreased: Zn 12.46 μg/l, Cu - 18.65 μg/l, Cd - 0.19 μg/l, Pb - 6.54 μg/l, COP - 0.011 μg/l, that corresponds to the faintly polluted water area. So, this way of water area clearance is the most convenient and perspective.

Accumulation of heavy metals, chlorine organic pesticides and feeding relationships in hydrocoenoses of Syrdarya delta. Hydrobionts, which has a big biomass in delta lakes, play an important role on toxicant distribution. Zooplankton presented by Cladocera as well as benthos species (Mysidacea, molluscs) accumulate HM and COP in high concentration. They extract all studied toxicant types; it depends of species, age and other peculiarities. HCCH concentration in Cladocera (Table 4) is upto 1.25 μg/kg, DDT – 5.6 μg/kg, Zn – 10.1 mg/kg, Cu – 1.8 mg/kg, Cd – 0.8 mg/kg, Pb – 3.4 mg/kg. Cladocera has a high accumulation possibility; HCCH concentration in their bodies is up to 30.0 μg/kg, DDT – 36.6 μg/kg, Zn – 25.4 mg/kg, Cu – 7.8 mg/kg, Cd – 1.74 mg/kg, Pb – 4.3 mg/kg. Benthos invertebrates accumulate COP: α and γ HCCH - from 18.66 to 45.93 μg/kg (maximum for lake ecosystems), DDT – 36.65 μg/kg, DDE – 71.8 μg/kg, persistent pesticides are "preferable". This accumulation of HM and COP from the water and bottom silt is the one factor of purification as well as pollutant transmission on food chains to the top – fishes.

Analyse of fish tissues, collected in Syrdarya and Kamyshlybash lake system, shows the high concentration of toxicants, especially Zn in muscles and liver; concentration of this elements is upto 66.9 mg/kg. In general, content of Pb and Cd is 2-4 times more than Stangard Sanitary Indices (SSI). All types of studied pesticides are observed in fish tissues. In summer 1997 fish muscles contained 14.15 - 26.14 μg/kg of α HCCH; 9.12 -18.46 μg/kg of γ

HCCH; 15.06-45.16 μg/kg of DDT and 13.04-26.14 μg/kg of DDE. In summer 1998 there were 11.96-23.56 μg/kg of α HCCH; 7.06-11.09 μg/kg of γ HCCH; 12.09-39.01 μg/kg of DDT and 11.53-21.05 μg/kg of DDE in fish muscles of the same species. In 1999 these indices are as follow: 9.13-20.16 μg/kg of α HCCH; 5.13-9.18 μg/kg of γ HCCH; 10.86-32.18 μg/kg of DDT and 9.13-19.09 μg/kg of DDE. The fish liver contains the more concentration of pesticides than in muscles; but this content also decreased from 1997 to 1999. In general, fish pollution by pesticides was decreased, though it needs research attention. This information shows that COP and HM continue to pollute the water systems of Aral Sea basin. The control of pollution in the basin ecosystems is necessary, for this, some indicator species of hydrobionts will be taken, such as Mysidacea, Cladocera from invertebrates and *Lucioperca lucioperca* or *Abramis brama* from fishes.

For studying the patterns of migration, transformation and dynamics of toxicants we observed the main components of food chains in Syrdarya delta:

1. water - zooplankton - fishes-planktophagous species – raptor fishes
2. Water - phytoplankton - macrophytes - fishes – fish raptors
3. Water - zoobenthos – benthophagous fishes – raptor fishes

The migration flows of toxicants with different indices of change were determined according to trofic chains. The extraction of COP from the water is coming according to the principle of "biological intensification" – increase of the COP concentration from the first chain to the top of food chains (raptor fishes).

Data show the gradual lowering of the pesticide content in water, bottom sediments; it is connected with decreasing of the chemical use in agriculture, high water level in Syr-Darya, lowering the land area in agricultural use. The result of this is a purification of delta lakes and toxicant transfer to the Small Aral Sea. Also, the decomposition process of the persistent pesticides, lowering of their concentration and change of them into metabolites with short life period (DDE and etc.) is observed.

3. New approaches in management of Barsakelmes wildlife reserve

Since the date of establishing (1939) the main goal of Barsakelmes Reserve has been determined as conservation of the wild nature ecosystems of North-Turan deserts as models of regional nature. Fortunately, there were no straight human impact on the area of strict nature reserve, but Barsakelmes Reserve was in the center of environmental changes connected to decreasing of Aral Sea water level. It caused some impacts to reserve and surrounding areas such as aridization, water and soil salinization, desertification and chemical pollution. These new environmental challenges requested new approaches in nature protected area management. So, since mid of 1980s in conditions of ecological crisis the additional and important goal of reserve management was formulated as: to provide monitoring observations of succession processes in wild nature ecosystems as well as to protect some wild species of animals and plants in conditions of environmental change impact.

In 1999-2000 the island Barsakelmes became a peninsula through the connection with eastern mainland coast because of decreasing of water level in Big Aral Sea. From that time some part of large wild mammals inhabited reserve-island in the past could escape to the continental deserts.

In spite of new environmental conditions the Nature Strict Reserve could survive as an important Protected Area for conservation of wild nature ecosystems, protection of some threatened species and monitoring of succession of wild nature ecosystems. What were efforts done for that by corresponded governmental agency, reserve administration and local community ?

Governmental Agency. In last several years Kazakhstan government through its special agency on PAs (Committee of Forestry and Hunting of Ministry of Agriculture of Kazakhstan) increased Reserve territory in several times and established dam to provide good water management in a region:

a) the area of the State reserve has been expanded in 2006 almost by 10 times including the territory of dry seabed. Now the reserve area is a unique "nature laboratory" for studying climate change, aridization, desertification of landscapes, changes of structure and compositions of ecosystems, nature adaptation to global changes of environment. Government supported increasing of the Reserve into two cluster areas: 1) former island Barsakelmes (the most valuable area) with surrounding dry seafloor; 2) former islands Kaskakulan and Uzunkair with surrounding dry seafloor (habitats for onager and Persian gazelle); 3) wetlands in the Syrdarya river mouth will be reserved in near future.

b) Government built a Kokaral dam in November 2006 (with financial support of World Bank) and isolated northern part of the Aral Sea with Syrdarya delta and income of river water. It allowed to increase water level of Small Aral Sea till +42 m absolute height (level of Big Aral Sea +33 m). Now Syrdarya delta is flooded as well as its shallow water area is going to be covered by reed (main habitat of water-birds). In future in delta area the new hygro-mesophytic meadow vegetation and riparian forest (tugay) with complex of wild animals will be naturally formed. Rehabilitation of the Syrdarya delta and northern part of the Aral Sea is very important for global bird migration as wetland area in migration route between Africa - West Asia and western part of North Eurasia.

c) Government increased the budget and staff number of nature reserve.

d) Government establish two new populations of Asiatic wild ass (onager) in central and southeastern part of Kazakhstan. In the end of 1980s some part of Asiatic wild ass population were moved by governmental conservationists to central part of Kazakhstan (southern part of Betpakdala desert) and to southern part of Balkhash Lake area. The main purposes of that re-introduction were to preserve population of Asiatic wild ass in Barsakelmes in conditions of limitation of fresh water there (salinization of Aral Sea increased because of water level drop, there was only one source of fresh water in island) and to establish 2 new onager populations for conservation of genetype variability.

Barsakelmes reserve administration built an effective protection system for whole continental territory, provide additional fundraising, attract broad circle of scientific institutions for providing ecological monitoring research and organized wide propagandistic activity in national and local mass-media resources (TV, radio, newspapers, journals):

e) several new protection posts were organized in eastern side of PA with border signs and notice. Some security guards live in village (Karateren) among the local community, in that case guards could establish good relationship with local people, provide PR and effective control of violations (fire, penetration to reserve territory, illegal hunting, etc). Security guards were equipped by cars, mobile radio connection systems, optic instruments, etc.

f) protection system has a special goal to conserve the threatened species from Red Data Book (in Kazakhstan Red Data Book species are under the legislation protection) escaped from the reserve territory in time of local migration. There are many representatives of Red Data Book among animals: onager, Persian gazelle , 25 species of birds, 2 species of invertebrates. In 2002-2004 after joining island with continent the some part of large mammals moved to the surrounding continental deserts (west part of Kyzylkum desert). According to 2006 counting there were about 246 onagers in Kaskakulan area and 54 Persian gazelles (as well as 150 saigas) in Barsakelmes former island. In that time about 1000 Persian gazelle moved to Kyzylkum desert in the south-eastern coast of the Aral Sea.

g) several small projects devoted to nature conservation in Barsakelmes reserve were implemented in the area supported by different non-governmental funds.

h) several scientific institutions such as academic institutes (Institute of Botany, Institute of Zoology, Institute of Geography, Institute of Soil Science), Tethys Scientific Society, Center of GIS studying "Terra", etc. inside Kazakhstan and some scientific institutions from abroad (St-Petersburg University, Zoological Institute of RAS – Russia, Kyoto University and Tokyo University, etc. - Japan) provide some ecological basic and applied research in collaboration with Barsakelmes reserve stuff. Such international collaboration allows to continue ecological monitoring observations.

Some results of this scientific research devoted to environmental changes will be published in special monograph soon.

i) Some TV programs devoted to biodiversity conservation of Barsakelmes reserve were broadcasted in national (Khabar) and international TV (NHK, BBC World). Several video films were taken in collaboration with Kazakh, Russian, Turkish, Japanese TV journalists. Many articles in newspapers (Arguments and Facts, Izvestiya, Kazakhstanskaya Pravda, Kyoto Shinbun, Asahi, etc.) and journals (Didar, DM, etc.) were published.

Local community was involved to nature conservation in a region (including Barsakelmes reserve) through some local NGOs (Aral Tenizi, Baitak Dala, etc.) as well as international organization (UNDP, GEF small grant Program, WWF, Danish Fishers, etc.). The main goal of collaboration with local people – to decrease the anthropogenic press to nature ecosystems. There purposes of local community involvement are: to find economic niche for former fishermen, to find alternative sources of energy (wind, solar instead of wood) struggle against poverty (organizing small business), to distribute ecological knowledge, ecological education of children. Special attention of local community in nature conservation was directed to Syrdarya delta system of lakes. It is important area for economical activity (hunting, fishing, haying).

Future. At present time the conservationists propose an idea to establish a biosphere reserve on the base of Barsakelmes Nature Reserve. New form of protected area is important for strengthening nature protected system and interaction with local people for sustainable use of natural resources and development. The main idea of biosphere nature reserve is to combine wild nature and human economic activity for sustainable development of whole northern region of the Aral Sea. It is attempt to find balance between man and nature.

It is difficult to protect regional significant components of biodiversity outside of limited area of Barsakelmes strict nature reserve. For example, saxaul forests (*Haloxylon* spp., main tree in the Aral Sea), the Syrdarya delta wetlands and floodplain meadows, shrublands and forest plantations in the dry seabed with dominance of rare and endemic species, Turan desert plant communities and numerous habitats of Red Data Book species of flora and fauna. Large mammals expanded own distribution areas from Barsakelmes former island to continental deserts (on 300-400 km). Some part of Asiatic wild asses migrate to irrigation canals in summer time because of lack of drinking water in Barsakelmes, they come back to the peninsula in winter. Small herds of *Saiga tatarica* are observed in broad territory (everywhere, but mostly in Barsakelmes). A big part of Persian gazelles moved to Kyzylkum desert and Karakalpakstan (southern Aral Sea area in Uzbekistan) and stay out of PA. In that case establishing biosphere reserve is extremely important for future of conservation system in northern part of the Aral Sea.

There are some possibilities for establishing a biosphere reserve on the basis of the Nature Reserve Barsakelmes in future. New form of protected area will be an important link in the process of strengthening the protected regime in a core zone, the interaction with local people for a sustainable development of the area. The realization of "North Aral Sea" hydrological project (the dam and an improved canal system for irrigation) supported by the World Bank will provide a first stage of such efort – the creation of optimal abiotic conditions for ecosystem existence including wetlands, coastal and marine biotopes. Next step for the formation of stable ecosystems and biodiversity restoration is establishing special protected regime within biosphere reserve. The Biosphere Reserve is the most efficient form of regulation of nature conservation and socio-economic activities supporting a sustainable development.

4 Lessons for other wildlife reserves

During last 10 years the territory of the Reserve was transformed from island to mainland because of the sea water level decrease. Environmental changes happened in huge area of the Aral Sea. The processes of aridization, desertification, chemical pollution brought a lot of ecological troubles to nature and local people living in north and east part of the Aral Sea coast. At the same time in last 5 years in conditions of quick economical growth of Kazakhstan the republic government could accumulate financial support to this area and develop protected area system. The territory of Barsakelmes Nature Strict Reserve was expanded in ten times. Management quality and capacity building of Reserve were increased. In such modern conditions experts propose the idea to establish new form of PAs in this region - Biosphere Reserve.

The experience of Barsakelmes strict nature reserve in last 10 -15 years could be used by other nature protected areas administration and experts in the world.

a) the first lesson: it is important to formulate (improve, add) management goal of PA in new ecological conditions, and after that to get governmental support (financial and intellectual) for implementation of such goal in connection with rehabilitation of whole region.
b) The second lesson: to strength the management of protection service.
c) The third lesson: to establish ecological monitoring observation.
d) The fourth lesson: to establish good relationship with local communities for control of violation in protected area.
e) The fifth lesson: to attract an attention to PA from the broad circle of scientific institutions, local and national NGOs and international organization.
f) The sixth lesson: to organize propagandistic activity of PA in mass-media.
g) The seventh lesson: to provide own fundraising.

References

Akhanov J., Karazhanov K., 1998. Soil transformation in the delta plains of the Syrdarya River by anthropogenic desertification. *Sustainable use of natural recourses of Central Asia. Almaty: 20-23.*

Bekenov A., Kovshar A., Jashenko R., 1998. The problems of animal world conservation in the Northern and the Eastern Aral Sea region. *Sustainable use of natural Resources of Central Asia. Environmental problems of the Aral Sea and surrounding areas, Tethys: 8-10.*

Bragin B.I. and Matmuratov S.A., 1998. Modern ecological and toxicological situation in the lake system of the Syrdarya delta. *Sustainable Use of Natural Resources of Central Asia, Environmental Problems of the Aral Sea and surrounding areas, Tethys, Almaty: 158-160.*

Demchenko L., 1950. Vegetation of Barsa-Kelmes island as forage basis for ungulate animals. In: Proceedings of State reserve Barsa-Kelmes. *Alma-Ata, 1: 6-37.*

Dimeyeva L., 2004. Ecological peculiarities of vegetation forming of north-western coast of the Aral Sea. *Problems of desert development, 4: 23-28.*

Dubitskiy A.M., Bragin B.M., Nilov V.I., Jashenko R.V., 1998. Persistent pesticides and heavy metals in the ecology of water ecosystems of Syr-Dar'ya River basin in Kazakhstan. *In: Ecological Research and Monitoring of the Aral Sea Deltas, a Basis for Restoration, UNESCO Aral Sea Project 1992-1996, Final Scientific Reports: 273-290.*

Eliseyev D., 1991. What is the matter with the Aral Sea: Is it perishing or relating to its former bounds? *Salinet, 5:81-82*

Karazhanov K., Haibullin A., 2001. Soils of dried bottom of Aral Sea. Scientific bases of reproduction of fertility, protection and rational use of soils of Kazakhstan. *Almaty: 161-166.*

Kazenas V., Mityaev I., Jashenko R., Kadyrbekov R., Ishkov E., Tleppaeva A., 1998. Composition, ecology and zoogeography of insects in the North Aral Sea area. *Sustainable use of natural Resources of Central Asia. Environmental problems of the Aral Sea and surrounding areas, Tethys: 119-123.*

Mitrofanov V., 1998. Ichthyofauna of the Aral Sea and its conservation. *Sustainable use of natural Resources of Central Asia. Environmental problems of the Aral Sea and surrounding areas, Tethys: 123-124.*

Mitrofanov I., Mamilov N., Skakun V., 2002. Ichthyofauna of Small Aral Sea, Preliminary Investigation. *Results of short-term field expedition of Kazakstanicus and Japanese scientists, sponsored by JRAK with support of Tethys Scientific Society Kazakhstan in August 2002, Almaty, Tethys: 1-37.*

Nekrasova T., 1979. Soil water-salt regime in South-East coast of the Aral Sea. *Problems of deserts development, 4:18-23.*

Pachikin K., Krivenko V., Erokhina O., Shildebaeva S., 2005. Dynamics of a soil cover of Kazakhstan Priaralie and Syrdarya River lower reaches. *Tethys Geographical Research I: 93-106.*

Scherbinina I., 1971. Main types of rangelands of North Aral region. *Productivity of rangelands of North Aral region. Hydrometeoizdat, Moscow: 96-128.*

Vasenko E., 1950. Ecology and distribution of saiga. *Proceedings of State reserve Barsa-Kelmes, Alma-Ata, 1: 38-115.*

Contacts and websites resources for further information. Additional information including photo gallery on the Barsakelmes Strict Nature Reserve is available in web site of network of IUCN expert on PAs of Central Asia (mainly in Russian) – http://iucnca.net